Effects of Body Position during an Afternoon Nap on Body Temperature and Heart Rate Variability in Healthy Young Japanese Adults

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原　著

Effects of Body Position during an Afternoon Nap on Body Temperature and Heart Rate Variability in Healthy Young Japanese Adults

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Abstract : **Objective** : To examine the effect of body position during an afternoon nap on body temperature and heart rate variability in young healthy Japanese participants.

Method : Within-subject laboratory experiment with two sessions. After sleep had been restricted the previous night, the participants were required to take a nap (60 min.) in a semi-recumbent position on a reclining chair at either 60 degrees (A) or 30 degrees (B) from the horizontal. The experiment was performed from 13 : 00 to 16 : 00 in the laboratory of Nursing Science in the School of Health Sciences, Faculty of Medicine, Kyoto University. An electrocardiogram (ECG), Polysomnography (Sleep electroencephalogram), core body temperature (rectal) and skin temperatures of the leg and foot were measured. Autonomic nervous function was evaluated by heart rate variability.

Participants : Eight healthy Japanese men aged 19 to 24 yrs.

Results : The decrease in rectal temperature during the first 20 minutes was greater in B than in A. There were no significant differences in parasympathetic function between A and B, while the sympathetic function in B was more activated after the nap. In B sleepiness declined significantly after the nap.

Conclusion : Napping in a posture similar to that when lying in bed deepened sleep adversely, with the possibility of a more prolonged phase delay.

Key words : Nap, Posture, Body temperature, Heart rate variability

In healthy people, brain fatigue due to daytime activity can generally be recovered by slow wave sleep (SWS) or non-REM sleep during the night. The appearance SWS coincides with lowest core temperature and "deep sleep"[1]. SWS have been reported to appear not only in a nocturnal sleep but also during a daytime nap. A daytime nap which includes SWS improves perceptual learning[2] and memory retention[3]. For these reasons, daytime naps may be an effective way for shift-workers to maintain their mental and physical performance ; however, hospital patients in Japan can suffer from a sleep disorder that prevents them from having a good night's sleep due to excessive daytime napping.

Daytime naps can promote wakefulness and health in general, but such a nap, particularly late in the afternoon, will delay sleep onset the following night[4] and it can be of little recuperative value if it results from boredom or exhaustion[5]. Therefore, advice given for insomnia-taking a daytime nap-could, in some cases, diminish the quality of the subsequent nocturnal sleep[6]. In addition, the problem remains as to whether daytime sleeps should be recommended for hospital-patients. There has been much discussion on the value of daytime naps for shift-workers and healthy people[7~9], namely, a short nap is useful for wakefulness and enhances performance[10,11] and an afternoon nap for 90 minutes by the elderly has a positive effect on evening performance, but it also has a negative effect on nocturnal sleep[12]. Many reports have discussed the appropriate time and duration for the nap ; however, the answer for hospital-patients is not yet clear. Another question remains : which body position is appropriate during a nap (particularly the effects of the back angle with respect to the horizontal) ?

On the other hand, as for autonomic nervous system activity, Pomeranz et al[13] reported that the parasympathetic system became dominant in the supine position and the sympathetic system became dominant in the standing

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position. The day-night variation over 24 hours has been clear for autonomous nerve activity, but no attention has been paid to the effects of posture[14,15]. In addition, the effects of wake and sleep stages were studied on the 24-h autonomic control of blood pressure and heart rate in recumbent men[16]. Likewise, even in patients with chronic heart disease (CHD), the effect of the posture was investigated on heart rate variability[17] and the right lateral decubitus position was recommend to decrease the sympathetic nerve activity for patients with CHD[18]. Thus, it is clear that posture —such a sitting, standing, supine, etc.— produces hemodynamic and metabolic changes[19], but the effect of the posture during a nap has been studied far less with regards to the autonomic nervous system. Acute sleep deprivation is associated with increased sympathetic nerve activity and decreased parasympathetic activity, together with decreased sensitivity of the baroreflex[20]. A previous report investigated sleep deprivation of 12 hours; however, it did not consider the relationship between the effects of sleep deprivation on the autonomic nervous system and the heart rate variability. In the nursing field, there has been a study on the backrest angle at the time of the cardiac output measurement[21].

At sleep onset, core body temperature in humans falls, because of heat loss via the distal skin regions (feet, hand) and this phenomenon induces sleepiness. Krauchi et al[22] performed an experiment to clarify the relationship between heat loss and sleepiness, changing body position at the same time from upright to a supine; however, few studies have mentioned the sleeping posture, including a nap.

To solve the problem, we have examined the effect of body position during an afternoon nap on body temperature and heart rate variability in young healthy Japanese participants.

METHOD

Participants

Eight healthy Japanese men (aged 19 to 24 yrs, mean age 21.1 yrs) were investigated. Participants were limited to mens who had relatively simple and androgen-based endocrinological system. They reported normal sleep-wake habits and did not complain of sleep-wake problems and were not the extreme phase type[23]. They gave informed consent prior to participation. The study was approved by the Ethics Committee of Kyoto University Graduate School and Faculty of Medicine.

Data acquisition

Body temperatures were logged at 1-minute intervals using LT loggers (LT-8, Gram, Japan). Rectal temperature (a measure of core body temperature) was recorded using a probe (LT-ST08-11, accuracy ± 0.01°C, Gram, Japan) inserted 10 cm past the anal sphincter. Skin temperatures (a measure of peripheral temperature) were also recorded, using probes (LT-ST08-12, accuracy ± 0.01°C, Gram, Japan) fixed to the skin with thin, air-permeable adhesive surgical tapes (Surgical tape; Nichiban, Japan). Skin temperatures were measured at the centre-left parts of the instep of the foot (foot) and left leg (leg) for an index of heat loss.

Polysomnography (PSG) was performed using a multi-channel biological amplifier (Bio-Top 6R12-4; NEC Sanei Instrument, Japan) with band-pass filtering between 0.1 and 30 Hz. An electroencephalogram (EEG) was recorded from 4 scalp positions using the international 10/20 system (C3-A2, C4-A1: all referenced to A1 + A2), as well as one channel of diagonal electroocculogram (EOG), submentalis electromyogram (EMG) and an electrocardiogram (ECG). The EEG amplifier was calibrated to 50 μV. Ag/AgCl cup electrodes were used for EEG; these were fixed with EEG paste (Ten20; D.O.Weaver Co. Ltd., USA). The remaining electrodes were attached with thin tissue paper. The ground electrode was placed on the forehead of the participant. The skin area at the EEG electrode site was cleaned by rubbing with a cotton swab saturated with ethanol and then prepared by a small amount of EEG and ECG skin prepping gel (Nuprep; Bio-Medical Instruments Inc., Warren, USA); it was then cleaned again with a cotton swab saturated with ethanol. The impedance between the two electrodes was measured with an electrode impedance device (Bio-top, 6R12-4, NEC Sanei Instrument, Japan) and deemed acceptable if below 10 kV.

EOG was measured with Ag/AgCl disposable electrodes (Blue Sensor N-00-S, Ambu, Denmark) filled with wet gel. Two Ag/AgCl holey cup electrodes were attached to the chin, 3 cm apart, with double-sided tape and filled with wet gel (Electro-gel; Electro-Cap International, Inc, USA) to measure the EMG. ECG was measured with two Ag/AgCl disposable electrodes (Blue Sensor N-00-L, Ambu, Denmark) from a lead II. EEG, EOG, EMG and ECG data were digitized with a 12-bit A/D converter (MaP222, NIHONSANTEKU Co., Japan) and collected on an IBM notebook PC (Map1058, NIHONSANTEKU Co., Japan). The sampling rate was 1,000 Hz.

The Kansei-gakuin Sleeping Scale[24] (KSS) was used as the Japanese version of the Stanford Sleeping Scale (SSS), developed by Hoddes et al[25] for subjective rating of sleep. This scale consists of seven points (1: active, vital, alert, 2: functioning at a high level, but not a peak, able to concentrate. 3 : relaxed, awake, responsive, 4 : a little foggy, drowsy, 5 : fogginess, beginning to lose interest in remaining awake, 6 : sleepiness, fighting sleep, woozy, 7 : almost drifting, sleep onset soon).

Procedure

The experiment was performed from 13 : 00 to 16 : 00 h in the laboratory of Nursing Science at School of Health Sciences, Faculty of Medicine, Kyoto University. Because the sleep pattern of normal young adult run on an approximately 90-minutes cycle[26), they were asked to reduce their sleep by almost 1.5 hours the previous night. After eating lunch, the participants arrived at the laboratory (room temperature : 26 ± 2°C, R.H. : 60%, light intensity : 400 lux) at 13 : 00 h. Participants changed into a 100% cotton short-sleeved shirt and long pants without socks. All electrodes, to monitor EEG, EOG, EMG and EEG and all probes for temperature measurement, were attached while the participants rested in a sitting position on the chair. They were recorded for all periods during the experiment, and the participants' heart rate of two minutes in the rest state before and after the nap was extracted for analysis, after answering the KSS questionnaire.

The two conditions were 60-minutes sleep in a semi-recumbent position using a reclining chair at 60 degree (A) or 30 degree (B) to the horizontal (Fig. 1). The order of conditions A and B was randomized. At the onset of the sleep period, the laboratory was placed in darkness. Participants for whom sleep had been confirmed by the EEG monitor were woken up after almost 1 hour. Participants who had not been able to reach stage 2 of sleep during the experiment were excluded when the PSG results were considered. Stage 2 was confirmed according to the criteria of Rechtschaffen and Kales[27)]. After waking the participants, the laboratory was illuminated to 400 lux, and the participant answered the KSS questionnaire after heart rate measurement for two minutes while at rest.

Data analyses

Raw body temperature data from each participant were averaged every minute.

Autonomic nervous function was evaluated by heart rate variability using the Lorenz plot method (Map1060, NIHONSANTEKU Co., Japan). A Lorenz plot was constructed, in which each adjacent R-R wave interval was plotted against the next R-R wave interval. The plot was rotated using trigonometric functions so that the diagonal axis became the X-axis. The standard deviations of differences along the X- and Y-axes of the rotated Lorenz plot were then calculated, yielding Toichi's[28)] values for L and T, respectively. The Cardiac Vagal Index (CVI) was calculated as the log (L × T) and the Cardiac Sympathetic Index (CSI) as L/T.

Values are expressed as mean ± SEM and $p < 0.05$ was considered significant. The data were analyzed by two-way analysis of variance with repeated measures ANOVA (RM-ANOVA, within subjects). Huynh-Feldt (H-F) statistics were used to adjust the covariance matrix for violations of sphericity (Mauchly). Although p values of H-F were based on corrected degrees of freedom, the original degrees of freedom were used. When the F ratio proved significant, Dunnet's multiple post hoc tests were applied to identify any significant differences between the means.

RESULTS

Changes of leg and foot temperatures and rectal temperature for 30 minutes from the start of sleep were compared between conditions A and B (Fig. 2A, B). Changes in leg and foot temperatures were not significantly

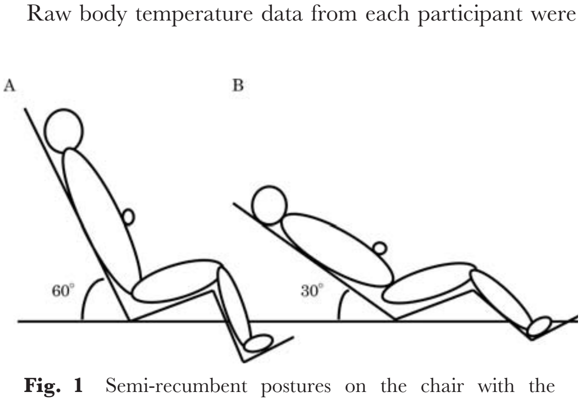

Fig. 1 Semi-recumbent postures on the chair with the elbow at 60 degrees (condition A) or 30 degrees (condition B) from the horizontal.

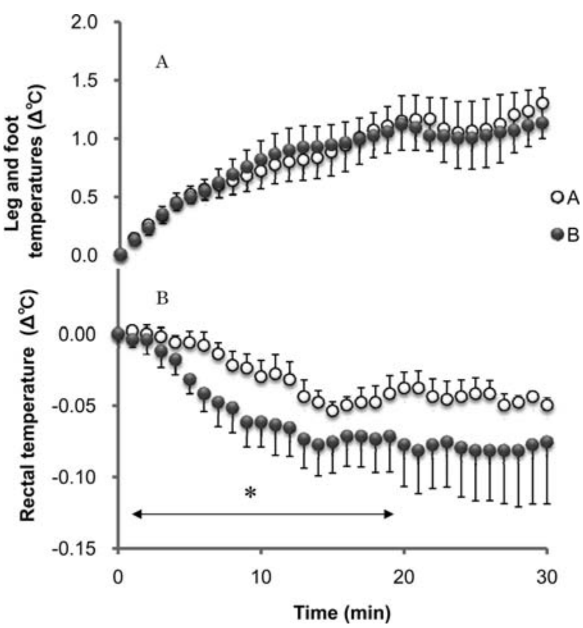

Fig. 2 Change of leg and foot temperature (A), rectal temperature (B) from sleep start after 30 min., mean ± SEM, zero indicating the value at sleep start. * $p < 0.05$. ○ A and ● B conditions.

Table 1　Change in cardiac autonomic mesurements and KSS score

Condition	A		B	
	Pre-sleep	After sleep	Pre-sleep	After sleep
CVI	4.50±0.7	4.66±0.20	4.65±0.14	4.75±0.12
CSI[a]	2.13±0.32	2.18±0.39	2.67±0.35	2.19±0.18
KSS[b]	4.19±0.31	4.27±0.26	4.00±0.31	3.58±0.35

Value are the mean±SE. [a]$p=0.042$ (position x time). [b]$p=0.015$ (position).

different between conditions A and B; however, rectal temperature decreased significantly more quickly in condition B in the first 20 minutes ($p<0.05$). The effect of the autonomic nervous system upon the heart was not different between the two conditions for CVI; however, for CSI, there was a fall after the nap ($p<0.042$, $F=7.34$). Scores in the KSS showed a fall after the nap in the B condition, but an adverse rise after the nap in the A condition ($p<0.015$, $F=10.39$) (Table 1).

DISCUSSION

Because a significant fall of rectal temperature was seen in this study, it appears that sleep was deeper in the B condition. This is supported from Berger's study[1]. Moreover, from the analysis of the R-R intervals, the nap in condition B lead to deep sleep, because a fall was seen in sympathetic nervous system activity and there was a significant fall in subjective sleepiness. These results accorded with those from the core body temperature data; however, it has been stated that sleep equal to or less than 20 minutes is effective in having a refreshing effect[29]. When the nap is taken in a posture to lying in bed, it may be difficult to finish a nap in 20 minutes as it will be an adversely deep and long sleep. There is also a possibility that the nap will induce phase delay of sleep-wake cycle[11].

In Japan, patients often spends all day in a hospital bed in the decubitus posture. The current results suggest that the posture of the patient during the daytime (associated with napping) might influence the following night's sleep. Maintenance of a posture that is not supine but near to a sitting position may be needed to avoid deep sleep during the nap; however, this study needs to be repeated with a greater number of participants and various age groups. Furthermore, it is remained for future work to investigate the effects of a daytime nap and the sleeping position on the following night's sleep.

CONCLUSION

It is beneficial for hospital patients to take an afternoon nap in a more semi-recumbent position for better performance after the nap; however, it can induce a more prolonged phase delay.

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